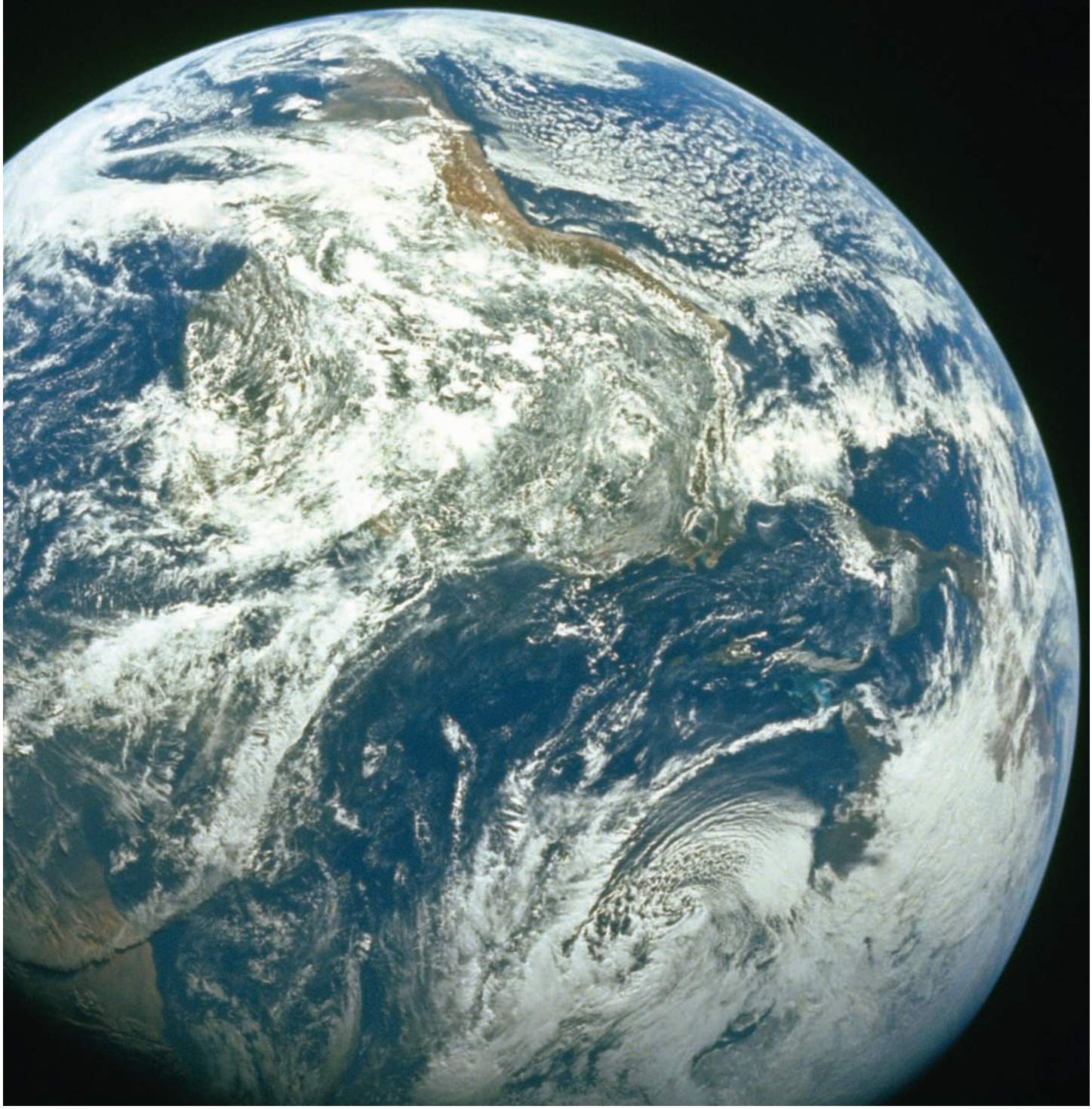
2009 Climate Change Research Strategy
Rocky Mountain Research Station



Contents

Rocky Mountain Research Station

http://www.fs.fed.us/rmrs

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Executive Summary

Climate change and shifting demographics influence the landscape and the social and economic systems of the Interior West. Climate change impacts are already evident, as seen in declining snowpacks, changes in runoff timing and intensity, increasing fire frequency and severity, increasing drought frequency and severity, and rising temperatures.

Determining the changing relationships between climate, various ecosystem components, and social and economic system components is critical to identifying management's role in adapting to new climates and/or mitigating climate change. Past research and the majority of resource management approaches assumed an unchanging climate. Opportunities exist to explore the relationship of past climates with historical disturbances such as drought, insects and fire in the context of the novel future climates.

Sustaining the health, diversity, and productivity of western landscapes will require adaptation and mitigation, as well as collaboration and cooperation across the organizational and geographic landscape. The Rocky Mountain Research Station (RMRS) has identified two critical areas for emphasis: **one relating to scientific understanding** (i.e., synthesizing completed RMRS research provides a basis for the development of new tools, management guidance, and enhanced knowledge) and **the other relating to natural resource management and planning** (i.e., land managers need to know not only how their decisions impact their ability to manage for climate change, and also how climate change may impact the various resources they manage).

This document was prepared to highlight the Station's climate change research and science delivery capacity to support the needs of its numerous clients. This document is organized into four sections. The first provides background material and includes an introduction, information on the context for the Station's climate change research and how science can support land management and planning. The second section outlines research opportunities based on emphasis areas outlined in the *2008 RMRS Strategic Framework Update:*

- Water Supply and Quality
  - Effects of climate change on water dynamics
  - Water resource effects on human and ecological systems
  - Adaptation options for water resources management under climate change
  - Trade-offs between carbon sequestration and water supply

- Aquatic species effects (including threatened/endangered/sensitive fish)

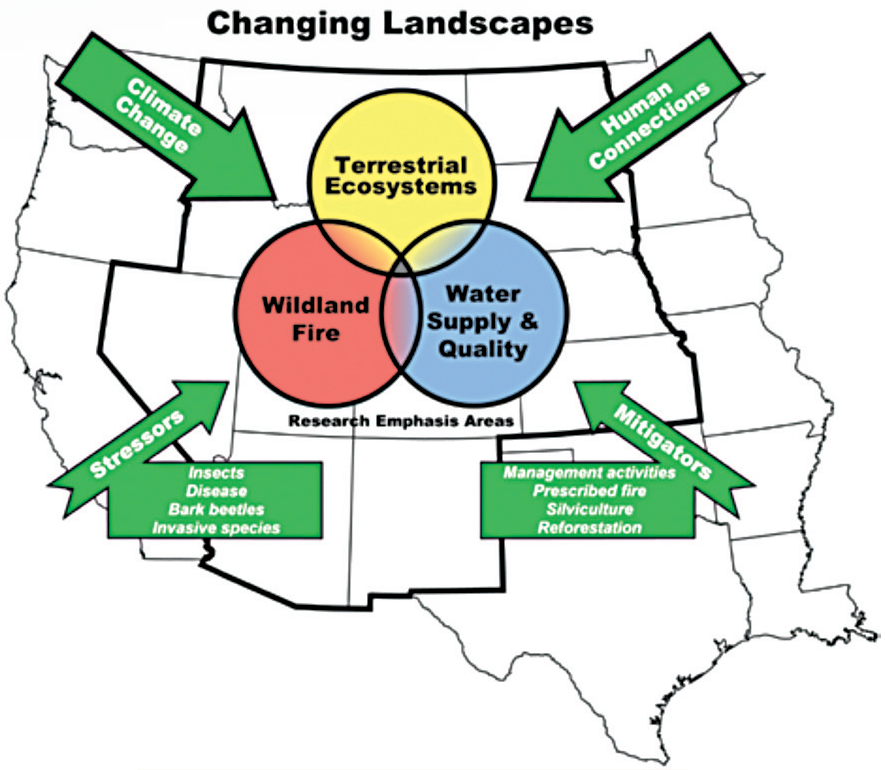
❖ Wildland Fire

- Fire regimes in a changing climate
- Emissions and climate change mitigation
- Fire and humans

❖ Terrestrial Ecosystems

- Monitoring
- Threatened/endangered/sensitive terrestrial species effects
- Changing patterns of exotic invasive species
- Carbon cycle dynamics in mitigation and adaptation

The third section addresses decision support science and science application and delivery opportunities. The fourth section provides concluding remarks. The scientific information, tools, and technology developed by the RMRS will provide a basis for decisions on natural resource adaptation and mitigation management actions in the West.



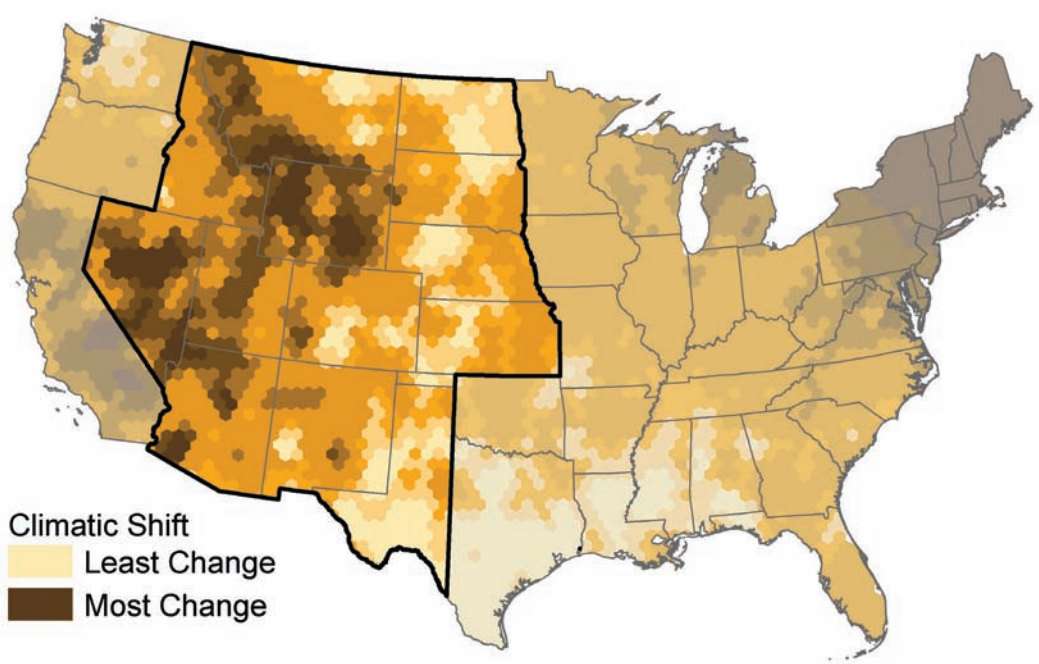
Future changes include the effects of climate change and human connections on terrestrial ecosystems, wildland fire, and water supply and quality in Interior West landscapes. These effects can be compounded by ecological stressors, or ameliorated by mitigators. Source: 2008 Strategic Framework Update. Note: This figure represents the most current RMRS boundaries.

Background Information

Introduction

The diversity of environmental conditions and landscapes across the RMRS territory—spanning from the Mexican border to the Canadian border—serves as a laboratory for studying climate change impacts in the Interior West. Within this area, 54 National Forest, and Grasslands sit among a mosaic of private, state, and other federal lands where wildlife, water, and disturbances move freely across boundaries. Human attraction to pristine environments has led to rapid urban expansion near previously undeveloped areas. Research to support natural resource management and policy-making must be tailored to these unique ecological, economic, and social condition.

Climate change is already evident in the Interior West in declining snowpacks, changes in runoff timing and intensity, increasing fire frequency and severity, increasing drought frequency and severity, and rising temperatures. Studies verify that average temperature increases in the Interior West are larger than national averages.



Areas of the Interior West are experiencing dramatic climate change. For more than 20 years, RMRS has housed ecologists and economists to lead assessments of climate change.

Sustaining the health, diversity, and productivity of western landscapes will require specifically tailored adaptation[1] and mitigation[2] strategies. This goal will also require that public and private land managers, urban dwellers, and the general public understand the changing climate's potential alterations to ecosystem services. Techniques are needed to assess the consequences of anticipated climate change to physical, biological, and socio-economic systems.

RMRS has strong science programs supported by a landscape-scale network of research natural areas and experimental forests, sites and ranges that together are designed to address critical Interior West research needs, including:

- Air, Water, and Aquatic Environments;
- Fire, Fuel, and Smoke;
- Forest and Woodland Ecosystems;
- Grassland, Shrubland, and Desert Ecosystems;
- Human Dimensions;
- Inventory and Monitoring; and
- Wildlife and Terrestrial Ecosystems.

The broad natural resource challenges associated with climate change require integration of the understanding and research provided by these individual programs. This document was prepared from a forecasting of client needs and highlights the Station's climate change research and science delivery capacity. Critical efforts are needed in two specific areas: **one relating to increased scientific understanding of climate change and its impacts on the ecosystems of the Interior West** (i.e., synthesizing completed RMRS research provides a basis for the development of new tools, management guidance, and enhanced knowledge) and **the other relating to natural resource management and planning** (i.e., land managers need to know not only how their decisions impact their ability to manage for climate change, and also how climate change may impact the various resources they manage).

[1] Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007). The Forest Service *Strategic Framework* identifies two major categories. *Anticipatory* actions intended to prevent serious disruptions due to changing climate may include thinning of forests to increase tolerance to drought and resistance to wildfire or insects, genetic conservation of species, assisted migration of species to suitable habitat, development of wildlife corridors to facilitate migration, or construction of new water storage facilities. *Opportunistic* actions that take advantage of human-made or natural disturbance events to facilitate adaptation to future climate may include planting different species or genotypes from those that occurred on a site before disturbance, or active conversion of vegetation structure to make it more resilient to changing climate.

U.S. Department of Agriculture, Forest Service. 2008. 2008 Strategic Framework Update. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 16 p.

[2] Mitigation is an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases through efforts such as energy efficiency or increasing the carbon sequestration of carbon in ecosystems.

IPCC; Core Writing Team; Pachauri, R.K.; Reisinger, A., tech eds. 2007. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland. 104 p.

Integrating RMRS research provides a basis for new tool development, management guidance, and enhanced knowledge. RMRS also integrates across disciplines to develop multi-disciplinary models or families of such models designed to answer specific questions. The Station's forest and woodland growth models (for example, Fire and Fuels Extension to the Forest Vegetation Simulator and SIMPPLLE) are being updated to incorporate the latest science on growth, mortality, interactions with insects and diseases, fire and fuel dynamics, links to soil erosion, and climate change to allow managers to explore alternative scenarios.

In addition to providing scientific information, tools, and technology for natural resource adaptation and mitigation management actions in the Interior West, RMRS also has enacted sustainable operations goals and ethics for the workplace. RMRS leadership has signed a *Sustainable Operations Vision Statement* (appendix) that details actions to reduce activities that contribute to climate change, thereby lessening the Station's environmental footprint.

Context for RMRS Climate Change Research

Climate change and shifting demographics continue to influence the ecological, social, and economic systems of the Interior West. Stressors such as air and water pollution, fragmentation of habitat through rapid urban and industrial development, insect and disease infestations, extended drought, and unnaturally severe fire events affect and are affected by climate change.

Determining the changing relationships between climate, various ecosystem components, and social and economic system components is critical to identifying management's role in adapting to new climates and/or mitigating climate change. Past research and the majority of resource management approaches assumed an unchanging climate. Opportunities exist to explore the relationship of past climates with historical disturbances such as drought, insects and fire in the context of the novel future climates.

RMRS climate change research is influenced by the following efforts and documents:

- United Nations Intergovernmental Panel on Climate Change
- U.S. Climate Change Science Program (CCSP)
- U.S. Department of Agriculture Strategic Goals
- Forest Service Strategic Framework for Responding to Climate Change
- Forest Service Research and Development Global Change Research Plan (FSGCRP)
- Forest Service Research and Development West-Wide Climate Initiative (WWCI)
- Forest Service Strategic Plan
- Forest Service Rocky Mountain Research Station Strategic Framework
- Partner efforts and client research needs

The bulk of this document outlines the climate change research capacity under the key components of the RMRS *Strategic Framework Update*—water, fire, and terrestrial ecosystems—for the next 5 years. Each section begins with a short description of the importance of the resource and anticipated climate change impacts and is followed by a bulleted list of proposed research needs.

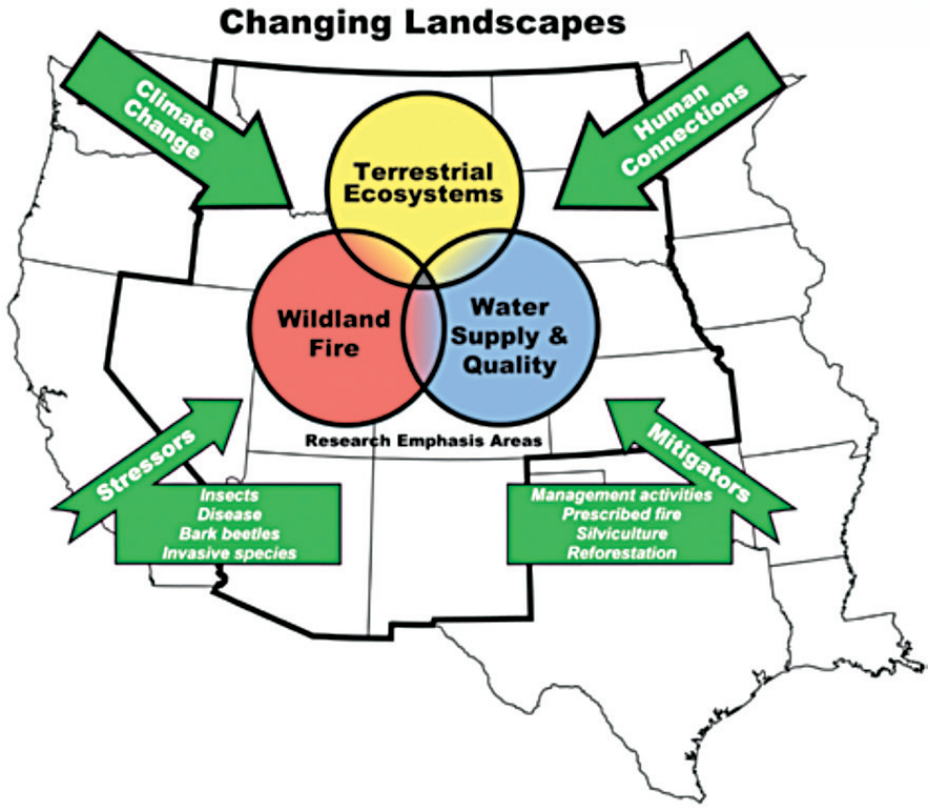
Science to Support Resource Management and Planning

Research synthesis assessments are needed to support land managers. Studies and tool development must be viewed from a climate change adaptation and/or mitigation perspective. Land managers need to know not only how their decisions impact their ability to manage for climate change, but also how climate change may impact the various resources they manage.

RMRS personnel have worked with land management partners to identify research needs for the next 3 to 5 years. Some key questions include: What does climate change mean to on-the-ground land management? How do we plan future land management activities under a changing climate? How do we continue to produce the suite of needed goods, services, and values under a changing climate? Related to these questions, three areas seem to offer the most potential for short-term payoff. They are: (1) syntheses of existing scientific knowledge in disciplines that most directly relate to management problem areas under climate change; (2) workshops designed to increase participant understanding of the implications of climate change on

ecological, social, and economic systems; and (3) the development of case studies on how to incorporate climate change considerations into management and planning activities.

The Forest Service (FS) has issued guidance for forest planning and NEPA project planning related to climate change. RMRS anticipates an increase in requests for scientific assistance as more forest and project plans attempt to use this guidance and address climate change. RMRS plans to work with Forest Service Regional partners (Regions 1, 2, 3, and 4) to develop collaborative climate change strategies and increase our integration efforts.

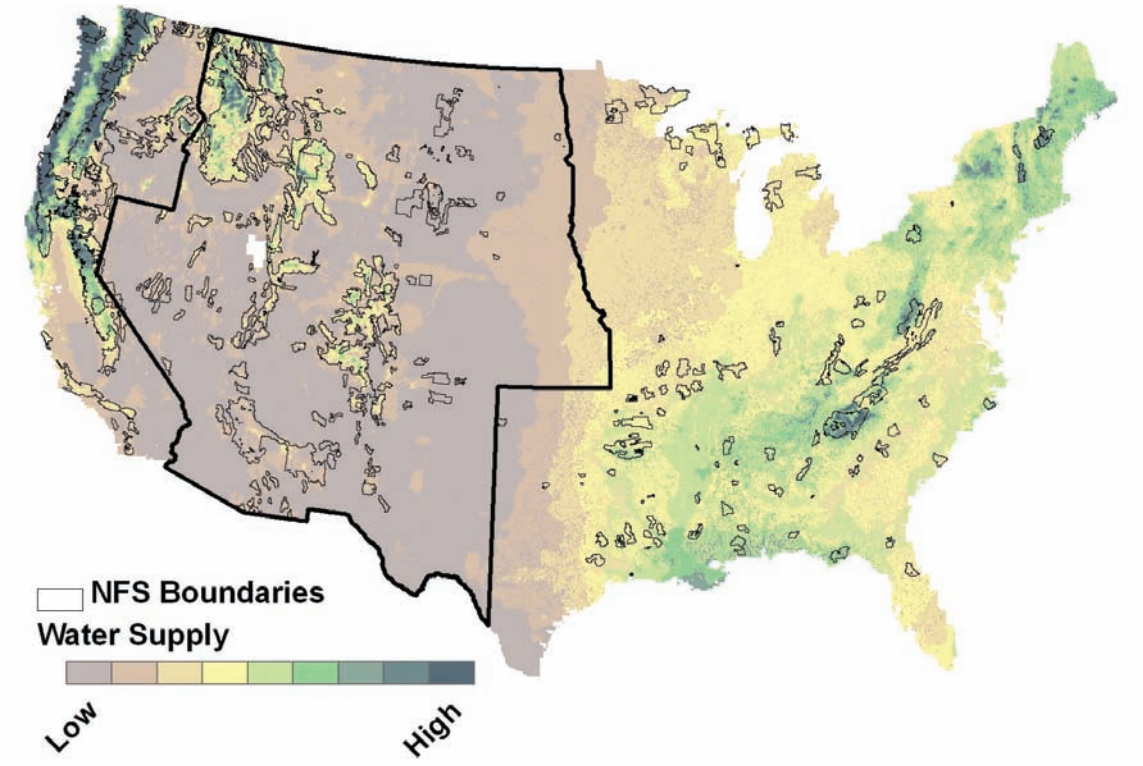


Climate Change Research Needs

Water Supply and Quality

Climate and water have always shaped the Interior West ecosystems, landscapes, and human lifestyles and have profoundly influenced social and economic systems. Water from National Forest System (NFS) lands provides, maintains, and supports a wide variety of ecological and societal services, such as recreation, aesthetic values, and genetic stocks. RMRS scientists are leaders in the study of water and its relation to those systems and services.

Climate greatly influences aquatic systems and the hydrological regimes of western watersheds. Observed and projected climate changes within the Interior West include warmer temperatures, and, in some areas, increased rainfall intensity, or drier conditions. Observed changing temperatures affect snowpack, runoff, and in-stream flows in western rivers. Climate change is altering disturbance regimes, such as fire, insects, and drought, that affect water yield. Attempts to increase carbon (e.g. increasing forest biomass and forest productivity) may exacerbate the adverse effects of climate on water



National Forests produce much of the Interior West's water supply. RMRS scientists conduct issue-specific regional assessments because natural resource management issues vary geographically.

yield and vice versa. Forest Service (FS) lands in the Interior West constitute the majority of remaining habitats for numerous TES, including Chinook salmon, bull trout, steelhead, cutthroat trout and other salmonid fishes. Salmonids may be especially vulnerable to a warming climate given their strong dependence on cold water temperatures.

This section summarizes important water supply and quality research needs in five categories:

Effects of climate change on water dynamics

- Predict water quantity, quality, and timing based on current trends and under future climate scenarios so both water and land managers will have the information needed to modify management strategies in response to water related climate change impacts.
- Study relationships between climate drivers and watershed processes in order to create models to predict the impact of climate change at watershed and landscape levels.

- Determine hydrologic responses to climate-induced changes in fire frequency, intensity, and severity as well as to vegetation change across the Interior West in order to develop new water resource management strategies.
- Examine cumulative effects among climate change, management activities, and disturbances on water quality, quantity, and timing, in order to adjust water management and use.

Water resource effects on human and ecological systems

- Assess the effects on human economies, municipal and agricultural water supplies, human migration patterns, and other social and economic systems.
- Determine how water management strategies such as water storage and diversion will evolve in anticipation of changes to available water supplies from Forest Service lands, and how these changes will influence land management strategies relating to water and possible ecological effects of water management.
- Evaluate impacts on water-related recreational opportunities.
- Estimate how extreme event disturbances and their relationships to flow variation, thermal qualities, and channel configurations will change.
- Develop and validate new remote sensing technologies in order to accurately and rapidly assess resource inventories.

- Develop cost effective and efficient monitoring strategies to detect aquatic ecosystem responses to climate change and evaluate the effect of changing stream volumes and flow rates on exotic organisms in riparian areas.

Adaptation options for water resources management under climate change

- Develop strategies for meeting or managing the needs/expectations of water resource users on FS lands and in downstream areas.
- Design water conservation strategies and assist managers with implementation.
- Work with managers to develop tools for implementing Best Management Practices on public roads to minimize run-off and maintain water quality.
- Determine the effectiveness of vegetation management (for example, fuel treatments, thinning activities, wildland fire use, and prescribed fires) for altering water supply and thermal regimes.
- Assess the effectiveness of road culvert modification and barrier removal for maintaining connectivity among aquatic habitats.
- Determine the effectiveness of road and trail decommissioning for altering water quality and supply.
- Assess the effect of various land management activities, other human activities and disturbance processes on water quantity, quality, and timing.

Trade-offs between carbon sequestration and water supply

- Identify the links among carbon dynamics, evapotranspiration, and the hydrological cycle and management's role in altering these dynamics.

Effects on aquatic species including threatened/endangered/sensitive fish

- Determine effects of climate change and fire on stream temperature and fish distributions.
- Assess effects on Federally listed fish species, such as bull trout.
- Determine which climate-influenced water resource attributes most importantly affect aquatic and riparian species.
- Forecast distributions of key water resource attributes to determine climate effects on size and connectivity of suitable habitats.

Wildland Fire

Fire is an important ecological process in the Interior West. A growing body of evidence suggests that climate change is already influencing fire behavior. Climate change alters the fire environment directly through changes in weather and seasonality and indirectly through changes in vegetation and fuels. One of the most effective approaches to investigating climate's possible influences on fire regimes is to examine data on how the two interacted in the past. Relationships between wildfire, ecosystems, and humans are complex and, therefore, require multidisciplinary research approaches. As climate changes, fire regimes, vegetation, and other ecosystem components will also change. Understanding these relationships is essential for developing effective adaptive management strategies.

Fire emissions contribute to atmospheric carbon and influence air quality and, hence, public health. Fire directly impacts humans through the wildland-urban interface, but humans have opportunities to ameliorate fire impacts through suppression and fuels management. Understanding public acceptance of various treatment options is critical in developing useful tools for managers. RMRS has a strong research program in fire fundamentals, fire ecology, and human dimensions as they relate to fire and is developing fire-related strategies for adaptation and mitigation.

This section summarizes important wildland fire research needs in three categories:

Fire regimes in a changing climate

- Investigate how the effects of changing climate alter fire intensity, severity, and occurrence.
- Determine how vegetation changes as a result of changing fire regimes and climate at a variety of scales.
- Predict how fire season and fire weather change regionally as a result of climate change.
- Develop methods for mitigating risks from short and mid-term climate variability and for incorporating climate change effects on fire regimes in forecasts and decision support models.
- Increase our understanding of the effects of increased fire frequency on

forest structure, fuels, and carbon storage at the landscape scale, and identify opportunities for forest/fuel management to ameliorate these effects.

- Use techniques such as dendrochronology, pollen studies, and charcoal abundance studies to increase our understanding of the function of historic climate in driving fire regimes.
- Determine how climate-driven changes in fire severity will affect post-fire soil erosion events and design fire restoration strategies that will best ameliorate these effects.
- Investigate how climate change will alter fire regimes in ways that impact species diversity and develop management strategies to increase the resilience of communities to maintain diversity.
- Predict ways that changing fire regimes interact with other biotic and abiotic disturbance agents, such as insects, diseases, blowdowns, and invasive species.

Emissions and climate change mitigation

- Investigate fire's impact on climate change mitigation strategies, such as the use of vegetation management as a carbon sequestration tool.
- Predict expected emissions and measure actual emissions from wildfire and from forest management and fuel reduction activities, such as prescribed fire.
- Improve our understanding of how fire impacts opportunities to substitute biofuels for fossil fuels.
- Develop a physics-based comprehensive fire modeling system that will be suitable for modeling fire for global carbon accounting among other uses.

Fire and humans

- Develop approaches to train managers and other decision makers on wildfire risk perceptions.
- Develop methods to understand perceptions of people who live in the Wildland-Urban Interface in order to collaborate more affectively to manage fuels and reduce fire risk.
- Determine both where fuel treatments are most cost effective and which fuel management alternatives are most effective given changing vegetation and the desire to use carbon offsets.
- Identify the social effects of increased emissions, such as public health.
- Develop effective educational tools with partners related to wildfire and climate and simultaneously promote the importance of education.
- Determine the trade-offs between alternative spatially-based fuel treatment strategies under the influence of climate change.
- Develop spatial and temporal approaches for integrating fuel treatments and wildland fire use with other forest management objectives to protect communities and other values at risk.

Terrestrial Ecosystems

Climate change and disturbances altered by it will likely unravel existing relationships between plants and animals in unexpected ways. The resilience and adaptability of individual species vary—some may persist in existing locations, whereas others may move to seek environmental conditions within their physiological tolerances. Warmer and drier climatic conditions, changing plant and animal communities, and altered disturbance regimes may also provide new opportunities for insects, disease, plant, and vertebrate invasion. These synergistic effects will set ecosystems and landscapes on new trajectories, potentially resulting in novel combinations of plants, animals, and ecosystem services.

Researchers examine a whitebark pine sample for bark beetle damage. The native insect is thriving under changing climate. Warmer temperatures enable it to better survive winter months and produce new generations at a faster rate. Understanding the invasive-like insect's relationship with and response to climate change is a critical component of RMRS research.

In order to develop effective methods to manage the changing landscapes, we will need a greater understanding of ecosystem components, their relationships to climate, and management's role in manipulating changing landscapes. In addition, we need to understand the role that climate change mitigation measures, like carbon sequestration through forest management, forest products, and bioenergy, might play in future forest management. The RMRS territory contains most of the largest tracts of relatively undisturbed land (wildlands) in the lower 48 States. Collectively, the lands are a laboratory in which researchers can separate climate change effects from the effects of management activities and other causes.

RMRS personnel have expertise in forest inventory and analysis and in monitoring animal populations. RMRS scientists have established a unique niche in researching and monitoring terrestrial TES species that occur in the ecosystems most likely to be impacted by climate change and compounding fragmentation and habitat loss. Both wildlife and vegetation genetics research at RMRS will provide valuable cornerstones of understanding. RMRS also houses an extensive

invasive species research program that is examining how climate change may expand ranges for invasive species and/or may decrease the effectiveness of control measures. In addition, RMRS scientists are working to develop carbon sequestration baseline information to help evaluate long-term sequestration potential.

This section summarizes important terrestrial ecosystem research needs in four categories:

Monitoring

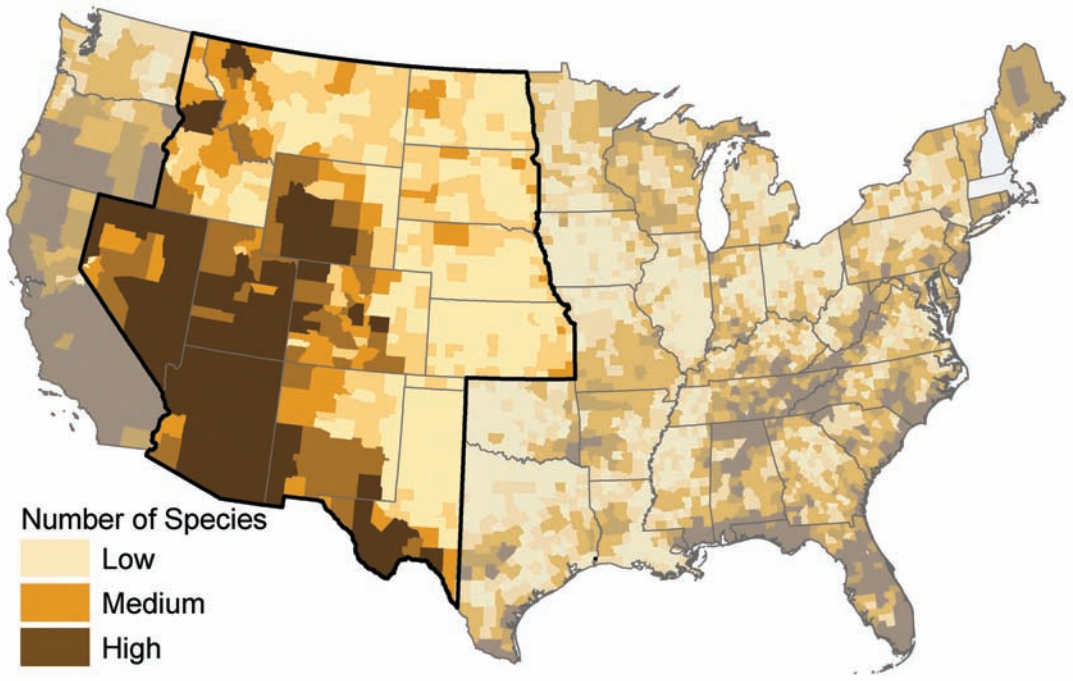
- Develop inventory and monitoring metrics designed to identify baseline and altered ecosystem functions so climate change influences can be distinguished from those of other anthropogenic stressors.
- Develop surveying and monitoring protocols/tools to identify climate impacts on threatened and endangered species.
- Seek opportunities to link existing inventory networks within the Forest Service (for example, Forest Inventory and Analysis) with other existing and planned networks, such as the National Science Foundation's Long-Term Ecological Research Network, the National Ecological Observation Network, and other monitoring programs within USGS and NASA.
- Identify methods and metrics to detect changes in ecosystem services to evaluate the attainment of management goals under a changing climate.
- Address carbon reporting and trading, quantification of ecosystem services, and global climate change research and policy analyses through strategic scale inventory and monitoring of the terrestrial vegetation resources in the United States.

Threatened/endangered/sensitive terrestrial species effects

- Investigate population connectivity of TES species using both genetic analyses and GPS studies of animal movements relative to climate-induced changes to habitat structure and composition.
- Improve our understanding of how TES species distributions will change, how environmental features will impart spatial variation in rates of change, and how conservation resources can best be allocated to sustain these species.
- Determine how climate-induced changes in landscape vegetation patterns affect persistence and viability of TES species.
- Determine how natural and human-induced disturbance processes affect the population viability of TES species and their habitats within the context of changing climates.
- Assess how increasing fragmentation and habitat loss due to climate change influence disease transfer from wildlife to humans and vice versa.
- Conduct assessments of wildlife, fish, and biodiversity and develop models that predict species' response to landscape and climate changes.

Changing patterns of exotic invasive species

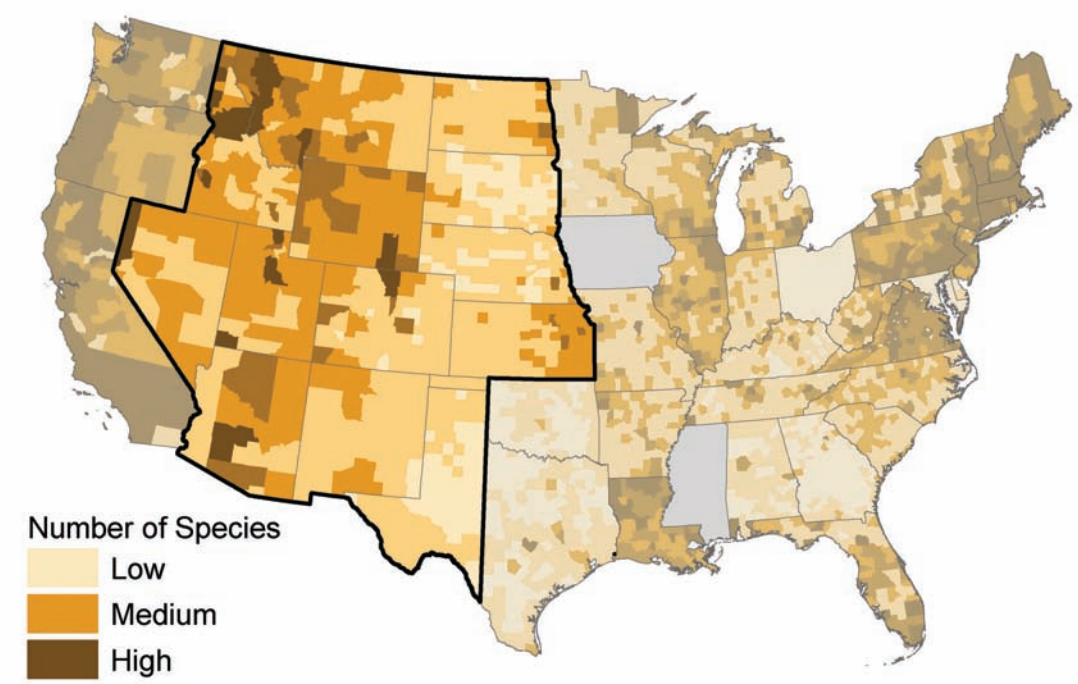
- Predict the potential range expansions of pest species, particularly terrestrial invertebrates and aquatic invaders, which are most likely to be immediately affected by changing temperatures.
- Assess the potential for shifting temperature and precipitation conditions to affect the invasiveness of exotic organisms and their impacts on native systems.
- Determine the likely implications of changing temperature and precipitation conditions on the effectiveness of invasive species management tools such as biological control, grazing, fire, and pesticides.
- Examine how drought driven by climate change and shifts in fire regimes may affect exotic species' invasive effectiveness and their impacts on native systems.
- Assess how changing precipitation and temperature affect the susceptibility of native systems to invasion.
- Develop improved science information on the relationships among invasive plants, native vegetation, natural and anthropogenic disturbances, climate change, and land management activities.



Large numbers of wildlife and plant species are at risk in areas of the Interior West. Large-scale assessments conducted by RMRS scientists provide reliable information for resource management planning on national, regional, and National Forest scales.

Carbon cycle dynamics in mitigation and adaptation

- Better understand the carbon dynamics in managed forest and woodland ecosystems, both in terms of effects on greenhouse gas emissions and effects on carbon sequestration, in order to better inventory the carbon sequestered in various carbon pools over time.
- Develop comprehensive and easy to understand syntheses of carbon cycle knowledge.
- Determine how changes in forest management, the timber processing industry, and fire patterns have affected the carbon cycle in the northern Rocky Mountains.
- Develop a 30+ year carbon-focused historical record of forest disturbance and re-growth dynamics in North America.
- Improve our understanding of carbon and nitrogen budgets and cycling in sagebrush/pinyon-juniper ecosystems.
- Assess fire frequency effects on forest structure, fuels, and carbon storage at the landscape level.
- Determine the effects of forest restoration on carbon storage in Colorado Front Range ecosystems.
- Identify the effects on soils and wildlife of removing varying amounts of forest products and biomass and those effects that arise from redistributing cut biomass for burning.



Rangelands throughout the Interior West are threatened by exotic invasive species. RMRS scientists collaborate on many related efforts because clients for large-scale assessments extend beyond the Forest Service.

Researchers measure the capacity of a contour-felled log erosion barrier (left) and examine sediment after a high-intensity rainfall event (right).

- Improve our understanding of below-ground decomposition, carbon sequestration, soil carbon, and organic matter pools as affected by climate change and forest management.
- Better understand the trade-offs between carbon sequestration objectives and other forest management objectives associated with alternative forest management systems and forest types in the Interior West.
- Quantify ecosystem exchanges of carbon dioxide in subalpine ecosystems using eddy flux research.
- Develop an understanding of the appropriate role and application of carbon trading/credits in forest and rangeland resource management.
- Quantify the relationships between mastication (chipping) of woody biomass and soil carbon.
- Develop methods to estimate carbon emissions from prescribed fires and wildfires.

Decision Support Science and Science Application and Delivery

Decision support science

Decision support information and tools can help identify trade-offs between different management activities and help to provide guidance for management of natural systems under changing climates. New short-term and long-term management strategies may be necessary in order to mitigate climate change; however, these strategies may affect various ecosystem values that are also at-risk. Planning for changing forest, grassland, and rangeland uses will require information on changing social preferences, as well as increased understanding of how these uses will affect terrestrial ecosystems under changing climates. One need in this area is to understand the relationship between human settlement/migration patterns and climate change. Understanding these changes and the resulting effects on TES species, invasive species, demand for forest products and biomass, as well as other ecosystem goods and services and resource trade-offs provides support for management decisions.

Quantitative methods and models can synthesize current and evolving understanding of climate change impacts on plants, animals, ecosystems, and social systems. RMRS scientists are well-positioned to enhance climate-vegetation models that can assist land managers in developing landscape projections, in addressing the uncertainty of future climates, and in exploring management options for adaptation and mitigation.

Research that will support planning and management efforts and improve our understanding of the potential impacts of climate change on ecosystem services include:

- Integrating understanding of how plant and animal communities and ecosystem processes will be altered by different climate change scenarios based on location, species composition, etc., in order to identify and evaluate management alternatives to facilitate adaptation to the changing climate.
- Improving our ability to project how changing climatic conditions, changing vegetation structure, altered disturbance regimes, and novel animal communities may enhance the potential for invasion by insects, diseases, plants, and vertebrates.
- Building on current efforts to characterize the relationships between at-risk species, invasive species, disturbances, and climate in order to develop management approaches to increase resilience.
- Developing approaches to work with agency partners and stakeholders to reconcile conflicting management goals within and across agency boundaries.
- Addressing how changing climates are expected to alter human values placed on natural resources, as well as improving our understanding of how human uses will affect terrestrial ecosystems.
- Incorporating climate change and carbon sequestration dynamics into current Forest Service management models, such as the Forest Vegetation Simulator.

- Developing methods to tier larger scale analyses and assessments, such as the Resources Planning Act Assessment, to forest and project-level planning.
- Incorporating uncertainty and risk into management decisions to adjust to unanticipated changes and to allow for flexibility.

Science application and delivery

Research results are of limited use if they are not applied to the management of natural resources. Getting research to managers requires an active science delivery program involving various forms of information exchange and communication. This exchange must initiate and maintain active partnerships and open dialogue between researchers and managers to ensure mutual understanding of knowledge and information needs.

New science application procedures are designed to help reach and inform a diverse audience through cost-effective and updateable procedures. Examples include:

- Enhancing the Climate Change Resource Center Web site (http://www.fs.fed.us/ccrc/), a one-stop reference (developed by the Pacific Southwest, Pacific Northwest and Rocky Mountain Research Stations) which contains relevant climate-related educational materials, as well as decision-support tools.
- Providing the necessary science support for project and forest planning and support for the development of conservation and restoration strategic plans for water dependent communities and species.
- Developing a shared NFS Research and Development Technology Transfer/Science Application cadre dedicated to defining research needs; developing science syntheses; packaging and delivering publications, models, and tools; inventory and monitoring procedures; and, hosting workshops, field reviews, and training sessions.
- Developing a network of demonstration watersheds to provide water and sediment yield information that can be used to conduct and display research results, and to provide a forum and link to land and water management issues and information needs.
- Creating partnerships with other Federal agencies to develop a land and water manager toolbox that would provide the latest models and monitoring procedures to predict and track management actions for mitigating the effects of climate change.
- Defining and developing decision support tools through researcher-manager roundtables to assist in linking available science and expertise.
- Developing a short-term, rapid response science delivery program that utilizes syntheses, case studies, and information technology tools to quickly distribute available science.

Conclusion

The purpose of this document is to provide our employees, partners, and clients with a sense of the Station's niche, capabilities, and role in climate change research and science delivery. Key components for this strategy's success are collaboration with our partners and clients to address land management program needs. While this document clarifies for our stakeholders and others what RMRS can do relative to climate change, it should be noted this is just a snapshot of activities that can and will rapidly evolve over the next several years.

Appendix—RMRS Sustainable Operations Vision Statement

We, the leadership of the Rocky Mountain Research Station, support a sustainable resource management, operations, and consumption ethic. We will create within our operations those habits that inspire individual and organizational decisions that lead directly to reducing energy use, water use, and waste production at our buildings and facilities; reducing emissions from transportation and travel; increasing fuel efficiency in our fleet; increasing recycling; utilizing sustainable landscape design; and, developing and implementing green purchasing practices.

We understand that achieving this vision requires active involvement from every employee in every staff area. Our goal is to enable employees to achieve this vision, not by adding work, but by asking employees to rethink the way that we do business. This requires a change in mindset towards more environmentally sound operations.

As we seek to achieve our vision, we will strive towards continual improvement, acknowledge our responsibility as leaders in natural resource conservation, share our learning, serve as an example to others, and work to fulfill the public trust. Some specific actions we will take to help us move towards this vision include:

1) Improving the energy efficiency of our facilities through energy efficiency audits, facility improvements, and the full utilization of tools like Energy Savings Performance Contracts.
2) Planning, designing, constructing, and operating new facilities that address "whole site" sustainable practices, and result in Leadership in Energy & Environmental Design certified or similar buildings.
3) Reducing fuel consumption and greenhouse gas emissions in our travel and transportation, by right-sizing our fleet, using more fuel efficient vehicles and hybrids, being selective in trips we take and conscious about our travel decisions, and by promoting carpooling, vehicle sharing, bicycling, and telecommuting (where appropriate).
4) Reducing water consumption by creating and implementing practices that support sustainable water resources and sustainable landscape design (e.g., xeriscaping).
5) Fully establishing and implementing green purchasing policies (with all employees that have purchasing authority) and ensuring that the appropriate green procurement, recycling, and waste minimization language is incorporated into service contracts.
6) Supporting and expanding recycling programs at our offices, which includes a Smart Paper Plan, plastic, aluminum, glass, electronics, furniture and equipment, etc.
7) Developing and utilizing pollution prevention plans and proper waste disposal guidelines for hazardous materials use.
8) Initiating and supporting the establishment of local green teams at our labs that will work to identify and implement place-based, grassroots sustainable operations activities.
9) Supporting appropriate employee involvement in activities and training related to sustainable operations.

Rocky Mountain Research Station Green Team
Changing habits today, conserving resources for tomorrow

This sustainable operations vision statement is hereby signed by all members of the Rocky Mountain Research Station Leadership Team:

G. Sam Foster, Station Director

Alison Hill, Deputy Station Director

Janine Powell, Assistant Station Director

Dolores Rottach, Assistant Station Director

Nick Reyna, Acting Assistant Station Director

Kerry Overton, Acting Assistant Station Director

Angela Baca, Civil Rights Director

William Block, Program Manager

Tom Crow, Program Manager

Deb Finch, Acting Program Manager

Colin Hardy, Program Manager

Frank McCormick, Program Manager

David Parsons, Program Manager

Michael Wilson, Program Manager

Cindy Swanson, Program Manager

United States Department of Agriculture

Forest Service

Rocky Mountain Research Station